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Analysis of economic viability under risk conditions of a beef cattle feedlot system in São Paulo State, Brazil

Análisis de viabilidad económica, en condiciones de riesgo, de ganado de ceba en un sistema de corrales de engorde en el estado de São Paulo, Brasil

Análise da viabilidade econômica, em condições de riscos, de um sistema de confinamento utilizado para a terminação de bovinos no estado de São Paulo, Brasil

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Abstract

Purpose: Assess the sensitivity and economic viability of the beef cattle feedlot system using as a reference a farm located in northern São Paulo State, Brazil.

Methodology: A multidimensional approach was used to assess sensitivity. Financial results were analyzed in terms of cash flow using the net present value (NPV) as a viability indicator. Risks were incorporated using Monte Carlo simulations, considering feed, animal purchase, and animal selling prices as discrete random variables. The value measure was NPV, calculated using a minimum attractive rate of return of 7.55% per semester. Probabilities were estimated by relative frequency analysis.

Results: The probability of a feedlot being economically attractive was 30.2%, indicating that the system was not viable in 69.8% of the cases. Sensitivity analysis showed that the feedlot was most vulnerable to fluctuations in selling price (a 1% increase in fed cattle price generated a 46% increase in NPV), followed by feeder cattle price (a 1% increase in feeder cattle price led to a 29% reduction in NPV) and feed price (a 1% increase in feed price produced a 12% reduction in NPV).

Contributions of the Study: The findings of this study may support new evaluations in representative samples, complement previous studies on the topic, and assist decision makers.

Keywords: Beef cattle. Feedlot. Economic viability. Sensitivity analysis.

Resumen

Objetivo: Evaluar la sensibilidad y viabilidad económica del sistema de corrales de engorde de ganado utilizando como referencia una propiedad ubicada en el norte del estado de São Paulo, Brasil.

Metodología: Se utilizó el enfoque multidimensional para evaluar la sensibilidad. El resultado económico se analizó a través del flujo de caja, siendo el valor presente neto (VPN) el indicador de viabilidad. Los riesgos se incorporaron con la simulación de Monte Carlo para los precios de pienso, compra y venta de animales que fueron las variables aleatorias discretas, la medida de valor fue el VPN, calculado con la tasa mínima de atractivo de 7.55% por semestre y las probabilidades se estimaron por la frecuencia relativa.

Resultados: La probabilidad de que los corrales de endorde de ganado sea una actividad económicamente atractiva fue del 30,2%, por lo que el sistema no fue viable en el 69,8%. En términos de sensibilidad, los corrales de endorde de ganado fue más vulnerable a las fluctuaciones en el precio de venta, el aumento del 1% en precio del ganado terminado generó un aumento del 46% en el VAN, seguido del precio de reposición, el aumento del 1% en el valor de ganado magro condujo a una reducción del 29% en el VAN, y precio de los alimentos, el aumento del 1% en el precio de una tonelada de materia seca redujo el VAN en un 12%.

Contribuciones del Estudio: Los resultados encontrados en esta investigación pueden respaldar nuevas evaluaciones en muestras representativas, incorporar estudios sobre este tema y ayudar a los tomadores de decisiones.

Palabras clave: Ganado de carne. Corrales de engorde de ganado. Viabilidad económica. Análisis de sensibilidad.

Resumo

Objetivo: Avaliar a sensibilidade e a viabilidade econômica do sistema de confinamento utilizado para a engorda de bovinos tomando como referência uma propriedade localizada no norte do estado de São Paulo, Brasil.

Metodologia: Utilizou-se a abordagem multidimensional para avaliar a sensibilidade, o resultado econômico foi analisado através do fluxo de caixa sendo o valor presente líquido (VPL) o indicador de viabilidade, os riscos foram incorporados com a simulação de Monte Carlo para os preços de alimentação, aquisição e venda dos animais que foram as variáveis aleatórias discretas, já a medida de valor foi o VPL, calculado com a taxa mínima de atratividade de 7,55% ao semestre e as probabilidades foram estimadas pela frequência relativa.

Resultados: A probabilidade de o confinamento ser uma atividade atrativa economicamente foi de 30,2%, conseqüentemente o sistema foi inviável em 69,8%. No âmbito da sensibilidade, o confinamento foi mais vulnerável à oscilações no preço de venda, o aumento de 1% no valor do boi gordo gerou o acréscimo de 46% no VPL, sendo seguido pelo preço de reposição, o aumento de 1% no valor do boi magro levou a uma redução de 29% no VPL, e pelo preço da alimentação, o aumento de 1% no valor da tonelada de matéria seca diminuiu o VPL em 12%.

Contribuições do Estudo: Os resultados encontrados nesta pesquisa poderão subsidiar novas avaliações em amostras representativas, incorporar os estudos sobre essa temática e auxiliar os tomadores de decisão.

Palavras-chave: Bovinocultura de corte. Confinamento. Viabilidade econômica. Análise de sensibilidade.

1 Introduction

Beef cattle farming is part of the primary sector of the economy. The activity can be divided into three phases, according to animal age and weight: breeding (cow-calf production), growing, and finishing. The breeding segment comprises females of reproductive age, bulls, and unweaned calves; growing comprises recently weaned animals that are raised for herd restocking and/or future slaughter; and the finishing phase comprises mature cattle that are fattened for slaughter.

Brazil has the largest commercial cattle herd in the world, with approximately 213.5 million head. In 2018, the country produced 9.9 million tonnes of meat and sold 2.08 million tonnes, ranking first in exports and second in global production, behind only the United States of America (USA), which produced 12.2 million tonnes. Despite occupying these prominent

positions, Brazil's livestock productivity is lower than that of global market players, with an offtake rate of only 18.6%. The USA has the highest offtake rate (35.7%), followed by the European Union (30.4%) and Australia (30%) (Food and Agriculture Organization of the United Nations [FAO], 2020, Foreign Agricultural Service/United States Department of Agriculture [FAS/USDA], 2020).

One of the factors explaining Brazil's low productivity is the predominantly horizontal expansion of farming, based mainly on the establishment of new pasture areas, large herds, and low investments in intensive systems. However, such a production model has become increasingly impractical because of the unavailability of agricultural frontiers, societal pressure for environmental sustainability, and the occupation of livestock land with higher-profitability agricultural crops. These factors underscore the need for investments and production technologies that allow reducing the animal life cycle and increasing scale and technical and economic efficiencies.

In feedlot systems, animals are confined to pens and supplied with controlled feed. According to Pires (2010), feedlot systems increase productive efficiency, reduce pressure on pasture areas, decrease variability in final product characteristics, increase slaughter weight, improve carcass quality, increase capital turnover, and allow for sales flexibility. However, their economic viability is sensitive to the volatility of feed prices and the ratio of animal purchase price to selling price.

Simões, Moura, and Rocha (2006) argued that, of the three phases of livestock production, the finishing phase has the greatest risk of variability in profit per hectare (R\$/ha), with a variability of 206.4%, followed by backgrounding (135.4%) and cow-calf phases (19.5%). The authors attributed this fact to the liability structure of each phase: whereas, in the finishing phase, 90.5% of the total liability was composed of circulating liabilities, in the cow-calf phase, this relation was of 44.9%. In 28.7% of cases, the financial result (R\$/ha) of the finishing phase was less than zero, but this phase showed the best results per hectare, reflecting the relationship between risk and return.

Feedlot systems can be used for the three phases of the livestock cycle, but, as a rule, they are mostly employed in the finishing phase. In Brazil, uncastrated zebu cattle with high potential for compensatory gain are generally subjected to finishing. Such animals are mainly used from April to December (dry season), and the feeding duration is shorter than that observed in Australian and USA feedlot systems. Meat from feedlot cattle is mostly sold in the international market (Pires, 2010, Millen, Pacheco, Meyer, Rodrigues, & Arrigoni, 2011).

According to the Brazilian Beef Exporters Association (ABIEC, 2019), in 2018, 12.6% of the cattle slaughtered in Brazil were finished in feedlot systems. The Anuário da Pecuária Brasileira (2016) showed that feedlot farms are located mostly in Mato Grosso, Goiás, Mato Grosso do Sul, and São Paulo States. Together, the four states hold 76% of feedlot cattle, and São Paulo State leads with 20% of beef cattle being finished in feedlot systems.

Given that (i) previous studies have focused on zootecnical aspects and given little importance to economic and financial factors, (ii) Brazil is one of the protagonists of meat production, and (iii) São Paulo is the major state in the use of feedlot systems, this study aimed to investigate the sensitivity and economic viability of a finishing beef cattle farm with a feedlot system in northern São Paulo State, Brazil.

2 Previous Studies

In the USA in 2018, 67.6% of beef cattle was finished in feedlot systems. Such a high use of confinement systems may be attributed to factors such as pasture availability, cattle

breeds, and carcass classification system. The economic sustainability of North American feedlot systems is critical, in part because of infrastructure and activity management practices. The number of farms with a capacity of more than 32,000 head has increased in the country as a strategy to mitigate the risks of the activity (Galyan, Ponce, & Schutz, 2011, National Agricultural Statistics Service/United States Department of Agriculture [NASS/USDA], 2020).

According to Queiroz, Reis, and Simões (2020), considering the economic aspects of beef cattle production, there are three modalities of feedlot management: exclusive, strategic, and partnership. Exclusive feedlot management is characterized by farms that acquire feeder cattle, subject animals to feedlot finishing, and then sell cattle to packing plants. Strategic feedlotting is carried out by rural producers that finish their animals by using surplus pasture. Partnership feedlot systems comprise farms that rent their facilities for other ranchers to finish herds.

A study conducted at the Department of Animal Science of the Federal University of Santa Maria (UFSM), Rio Grande do Sul, with 18 castrated crossbreeds (5/8 Nelore × 3/8 Charolais) fattened between August and September found that the probability of reaching economic viability was 70.1%. On average, the animals started the finishing phase with 361 kg live weight and reached 467 kg live weight. The variables that most affected the financial result were, in descending order, fed cattle price, feeder cattle price, fed cattle weight, and feeder cattle weight (Pacheco *et al.*, 2014).

Another study showed that the date of the beginning and end of the finishing phase influenced the financial result of feedlot beef cattle production in Minas Gerais. A 98.64% chance of achieving positive net present value ($NPV > 0$) was observed for the herd that began fattening on July 23 and remained until October 20. For the herd that was divided into two batches, with the first batch being finished from July 24 to October 13 and the second batch from October 15 to December 29, there was a 99.79% chance of achieving an $NPV \geq 0.00$. The probability of achieving an $NPV \geq 0.00$ was 83.08% for the herd that was fattened from October 1 to December 21 (Resende Filho; Braga; & Rodrigues, 2001).

3 Methodology

Data were collected from a feedlot located in northern São Paulo State with easy access to herds from other states, such as Goiás, Mato Grosso do Sul, and Minas Gerais. The farm operates year-round and has a housing capacity of 19,000 head. The sample included 1,200 uncastrated male Nelore cattle. Zootechnical data refer to the year 2016. Financial results were analyzed in terms of unconventional cash flow using the NPV as a viability indicator. Critical parameters were simulated by multidimensional sensitivity analysis. Calculations were performed using electronic spreadsheets.

The cash flow included the following outflows: freight bill, transportation invoice for animal purchase and sale, purchase and sales commissions, traceability, sanitary protocol and medicines, total operating expenditure¹, animal purchase, and feed. Cash inflows consisted of animal sales for slaughter. Cash flow data were collected between June 1 and November 30, 2016. All data were provided by the farm, except for animal purchase and selling prices. The Nelore feeder cattle price published by the Institute of Agricultural Economics (IEA) was used as purchase price. Revenues were calculated based on the fed cattle indicator of ESALQ/B3,

¹ Total operating expenditure was the term used by the farm manager. It includes all expenditure on labor, equipment maintenance, investments, fuel, depreciation, electricity, and charges. The farm did not report the contribution of each item to the total operating expenditure.

defined by the Center for Advanced Studies in Applied Economics of the “Luiz de Queiroz” School of Agriculture (CEPEA/ESALQ). Both institutions use data from the state of São Paulo for pricing.

The NPV provides a projection of future cash flows at present values based on a minimum attractive rate of return (MARR). A project is considered economically viable if the NPV is equal to or greater than zero. In the current study, the NPV was calculated under risk conditions using Monte Carlo simulation, a technique that applies random variables and a certain number of iterations. In Monte Carlo simulation, it is necessary to know the mean, standard deviation, and probability distribution of random variables, which are assumed to be independent (Blank, & Tarquin, 2008, Samanez, 2009).

Fed cattle, feeder cattle, and feed prices were chosen as discrete random variables. Means, standard deviations, and probability distributions were calculated based on price data for the period between June 1 and November 30, 2016. During this period, there were 115 quotes for fed cattle, 54 for feeder cattle, and 15 for feed purchases. The other cash flow items were kept fixed in the simulations. The opportunity cost was based on the Selic rate provided by the Central Bank of Brazil. The MARR was set at 7.55% per semester. The number of iterations was based on the least common multiple of the quotes of the three discrete random variables, resulting in 6,210 simulated values. This set has a similar coefficient of variation to the 1,000 and 2,000 simulations.

Multidimensional sensitivity analysis assesses the critical points of a project from two or more parameters and an analysis variable. Results are presented in a graph where the ordinate shows the percentage change of the output variable and the abscissa shows the percentage changes of simulated parameters (Blank, & Tarquin, 2008, Samanez, 2009). In the current study, we used fed cattle, feeder cattle, and feed prices as simulation parameters and NPV as an analysis variable.

4 Results and Analysis

The weights at the beginning and end of finishing treatments as well as the finishing period were pre-determined at 390 kg/head, 575 kg/head, and 120 days, respectively. These values are similar to those reported by Sartorello (2016), who evaluated five feedlot systems in São Paulo State with a minimum finishing capacity of 10,000 head. According to the author, the initial weight ranged from 346 to 360 kg/head, the final weight ranged from 498 to 540 kg/head, and the finishing period lasted from 100 to 136 days (Table 1).

Table 1
Performance results of the cattle fed

Variable	Value
Carcass yield	57.2%/animal
Daily weight gain	1.542 kg/animal/day
Net gain	105.45 kg/animal
Dry matter intake	11.03 kg/head/day
Feed conversion	7.15

Source: research data.

For the Monte Carlo simulation, freight, animal transportation invoice, purchase and sales commissions, traceability, sanitary protocol and medicines, and total operating expenditure were treated as fixed inputs (Table 2).

Table 2*Fixed parameters in cash flow*

Item	Value per animal
Freight	R\$ 70.48
Transportation invoice for animal purchase and sale	R\$ 4.82
Purchase and sales commissions	R\$ 17.38
Traceability	R\$ 3.20
Total operating expenditure	R\$ 226.19
Sanitary protocol and medicines	R\$ 8.13

Source: research data.

In 30.2% of the simulations, NPV was greater than or equal to zero; in other words, the chance of economic failure ($NPV < 0$) was 69.8%. This finding differs greatly from that obtained by Resende Filho *et al.* (2001). The authors found that, in the 1990s, feedlotting was used strategically to achieve the highest selling prices in the second semester; however, in the 2010s, the price volatility of cattle decreased, and differences between prices in the rainy and dry seasons were not significant.

The high probability of economic failure of the studied farm was associated with the selling price. The purchase price of fed cattle was determined using the ESALQ/B3 indicator, which represents market values without subsidies. In practice, however, feedlot farmers tend to sell cattle above the market price because, as highlighted by Pires (2010), feedlot cattle have high quality and carcass yield.

Figure 1 shows a histogram of the 6,210 NPVs simulated with an opportunity cost of 7.55% per semester. The interval $R\$ -80,000.00 \leq NPV < R\$ 0.00$ had the highest probability (27.9%). The probability of achieving the upper and lower intervals was minimal, 0.01% for the best result ($R\$ 240,000.00 \leq NPV \leq R\$ 320,000.00$) and 2% for the worst result ($R\$ -320,000.00 \leq NPV < R\$ -240,000.00$).

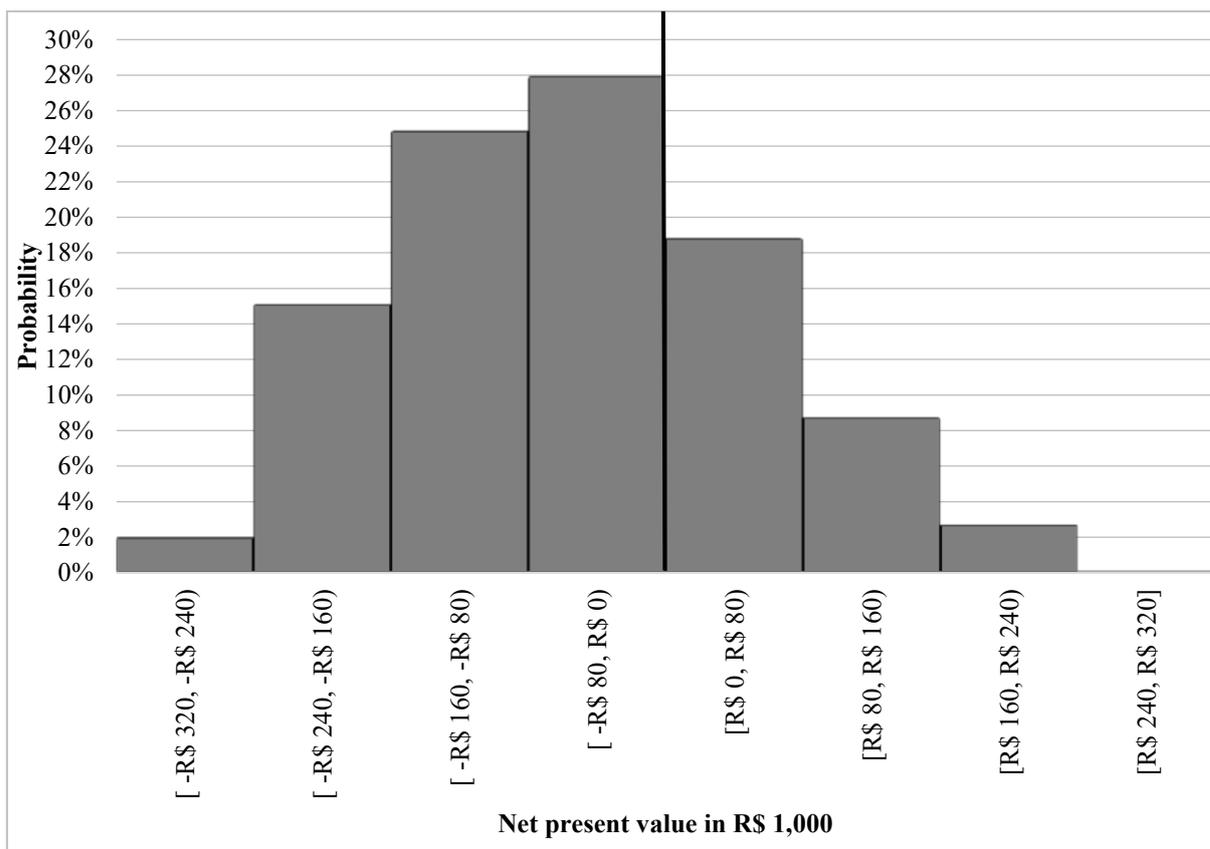


Figure 1 Histogram of net present value

Source: research data.

Cash outflows were mainly composed of animal purchase and feed. The representativeness of feed costs ranged from 25.1 to 28.6%, with 26% as the most frequent value. The contribution of animal purchase to cash outflow was 61.4–65.4%, with 64.1% as the most frequent contribution value (Table 3). These results are similar to those of Sartorello (2016) and Lopes, Ribeiro, Nogueira, Demeu, and Barbosa (2013), who evaluated feedlot systems in Carmo, Minas Gerais State, Brazil.

Table 3

Cost contributions

Item	Maximum	Minimum	Mode
Freight	2.2%	2.0%	2.1%
Animal transportation invoice	0.2%	0.1%	0.1%
Commissions	0.5%	0.5%	0.5%
Traceability	0.1%	0.1%	0.1%
Total operating expenditure	7.1%	6.4%	6.8%
Sanitary protocol and medicines	0.3%	0.2%	0.2%
Feed	28.6%	25.1%	26.0%
Animal purchase	65.4%	61.4%	64.1%

Source: research data.

Sensitivity analysis showed that the selling price of fed cattle had the greatest influence on NPV (Figure 2). If the prices of feeder and fed cattle remained constant, a 1% increase in

fed cattle selling price would lead to a 46% increase in NPV. In the case that revenue and feed costs remained the same, a 1% increase in feeder cattle price would lead to a 29% reduction in NPV. On the other hand, a 1% increase in the price of dry matter would reduce the NPV by 12%, considering that the other factors remained constant.

These findings agree with those of Griffith, Coddingtonm, and Murdoch (2004) and Pacheco *et al.* (2014). The first study revealed that the selling price was the most limiting variable to the financial result of a feedlot system in Australia and that an increase of US\$0.10 in the price (per kilogram) of fed cattle can lead to an increase of up to 17,430 animals in a feedlot system. The second study showed that the price of fed cattle is the most critical variable for the financial result of feedlotting, followed by feeder cattle purchase price.

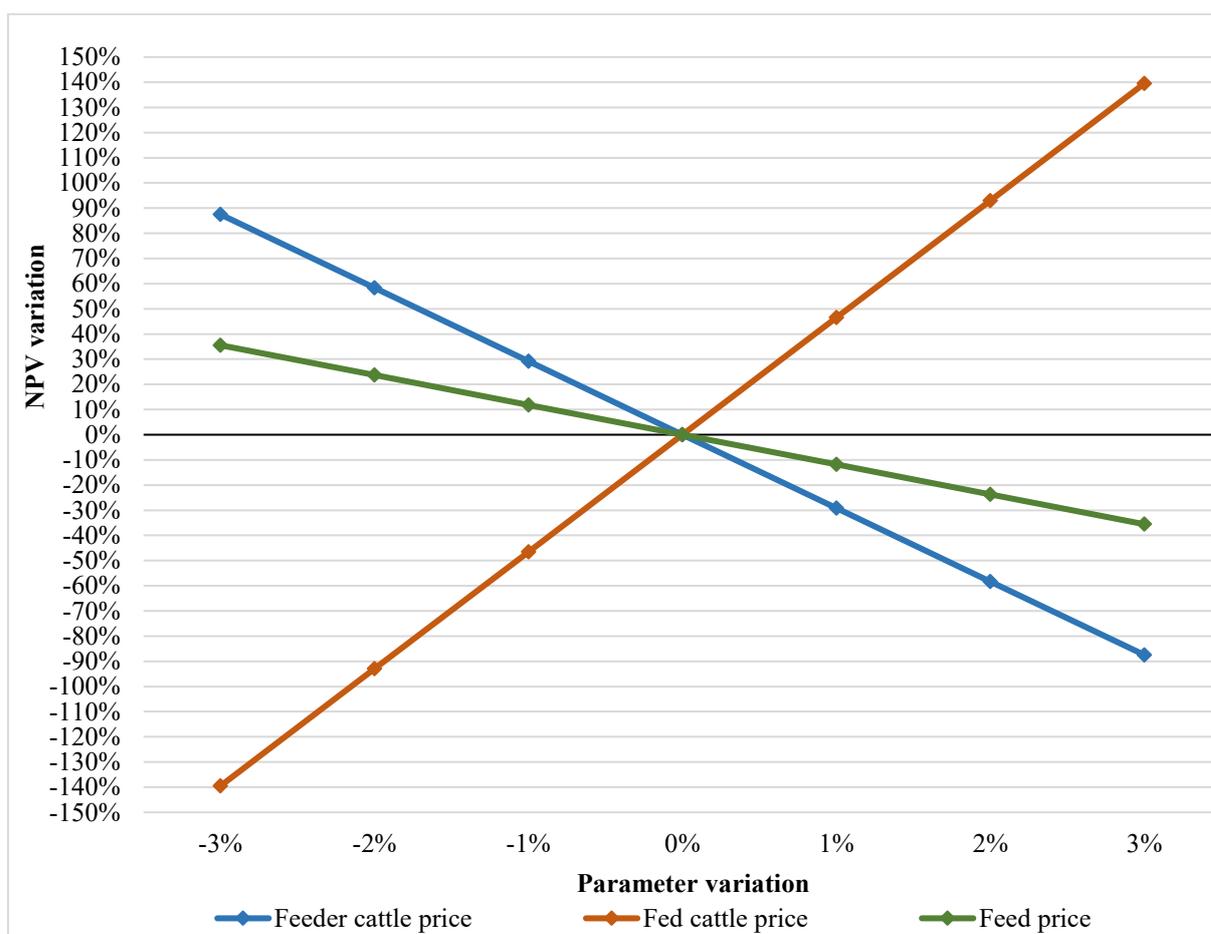


Figure 2 Multidimensional sensitivity of feedlot systems

Source: research data.

Although the price of fed cattle was the most critical to the financial result of the investigated feedlot system, its value had the lowest coefficient of variation ($CV = 1.9\%$), whereas the price of feeder cattle and feed had the same coefficients of variation ($CV = 2.9\%$). The 6,210 simulated prices of fed and feeder cattle ranged from R\$ 147.85 to 158.29/arroba and R\$154.17 to 174.48/arroba, respectively. The minimum and maximum prices of 1 t of dry matter were R\$ 657.52 and 717.51, respectively (Table 4).

Table 4*Discrete random variables*

Discrete random variable	Maximum value	Minimum value	Mean value	Coefficient of variation
Fed cattle price	R\$ 158.29 /arroba	R\$ 147.85/arroba	R\$ 152.50/arroba	1.9%
Feeder cattle price	R\$ 174.48/arroba	R\$ 154.17/arroba	R\$ 165.40/arroba	2.9%
Feed price	R\$ 717.51/t dry matter	R\$ 657.52/t dry matter	R\$ 679.40/t dry matter	2.9%

Source: *research data.*

Exclusive feedlot farms have a more complex economic management system than other systems, given that the two main inputs (feeder cattle and feed) are part of highly competitive markets. Furthermore, fed cattle represents a commodity. Therefore, feedlot farmers should seek strategies to mitigate economic risks, such as the use of agricultural derivatives for the purchase and sale of cattle and integration of feed production.

5 Final Considerations

The use of feedlot system beef cattle in São Paulo State optimizes the production cycle. However, this system may be economically unfeasible depending on market conditions. The costs of the activity are mainly composed of feed and of animal purchase, and the NPV is vulnerable to fluctuations in both expenditures. The most critical variable to the financial result is the fed cattle price, given that the NPV is more sensitive to variations in selling price.

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